(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 June 2001 (14.06.2001)

PCT

(10) International Publication Number
WO 01/42652 A1

(51) International Patent Classification[7]: F04B 1/20

(21) International Application Number: PCT/KR99/00746

(22) International Filing Date: 7 December 1999 (07.12.1999)

(25) Filing Language: Korean

(26) Publication Language: English

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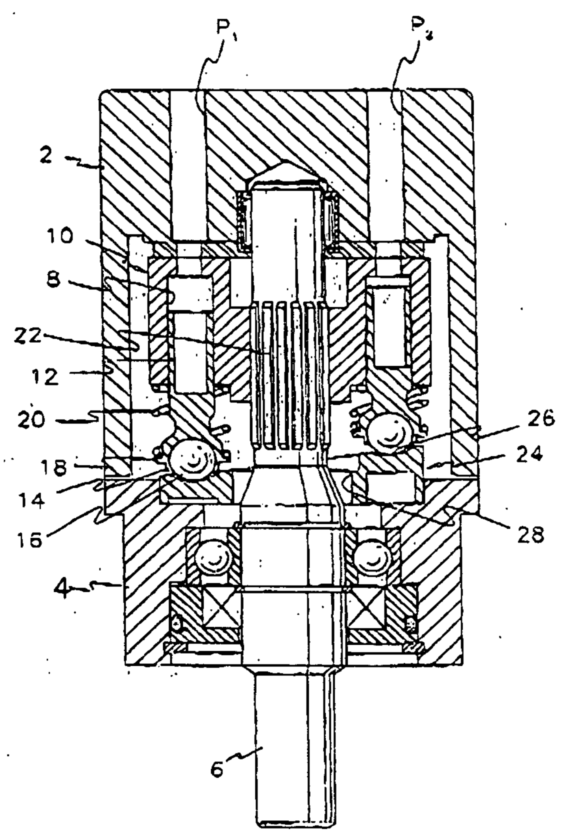
(81) Designated States *(national)*: AU, BR, CA, CN, HU, IL, JP, MX, NO, PL, RU, SG, US, VN.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published:
— *With international search report.*
— *With amended claims.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: HYDRAULIC PUMP



(57) Abstract: A hydraulic pump includes an upper housing with fluid inlet and outlet ports, and a lower housing combined with the upper housing. A driving shaft is inserted into the upper and lower housings such that the driving shaft is rotated. A cylinder block is mounted within the upper housing around the driving shaft such that the cylinder block is rotated together with the driving shaft. Uneven numbers of pistons are equidistantly arranged in the cylinder block such that the pistons reciprocate. Each piston has a ball bearing. A swash plate member is provided at the lower housing. The swash plate member has a spiral groove for receiving the ball bearing of the piston. The spiral groove of the swash plate member incurs the stroke of the piston. The spiral groove of the swash plate member has a left spiraled portion and a right spiraled portion interconnected by curved portions.

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HYDRAULIC PUMP

BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to a hydraulic pump and, more particularly, to a hydraulic pump which can significantly reduce variation in a quantity of fluid to be discharged.

(b) Description of the Related Art

Generally, a hydraulic pump is provided with a swash plate having an inclined side, and a cylinder block having a plurality of pistons each with a bottom end slide-contacting the inclined side of the plate. The pistons reciprocate in the cylinder block while sliding on the inclined side of the swash plate such that fluid is introduced into the cylinder block, and discharged therefrom.

In such a hydraulic pump, the quantity of fluid discharged from the cylinder block by each piston is formed with a sine wave, and hence the fluid quantity discharged by several numbers of pistons are overlapped with a form of an overlapped sine wave. This means that variation in the discharged fluid quantity, usually called the "pulsation", occurs. It has been known that such a pulsation phenomenon is due to the mechanical characteristics of the hydraulic pump or the fluid compression pressure of the pistons.

Most of the hydraulic pumps are installed with uneven numbers (for example, 7 or 9) of pistons because the uneven numbers of pistons involve reduced pulsation compared to even numbers of pistons.

Korean Patent No. 177496 to the present applicant discloses a hydraulic pump for reducing occurrence of the pulsation phenomenon with even numbers of pistons. The inclined side of the swash plate contacting the pistons is formed with a spiral groove.

In the above structured hydraulic pump, when the spiral groove of the swash plate is divided into first to fourth quarter parts from three o'clock to nine o'clock in the anti-clockwise direction, the top dead center of the spiral groove is positioned at the second quarter part, whereas the bottom dead center of the spiral groove at the third quarter part. This results in shortened fluid inlet stroke area, and hence increased fluid inlet speed.

Furthermore, the spiral groove formed at the inclined side of the swash plate should be deep-structured to receive the bottom end of the piston, and this involves complicated processing steps. In addition, when the spiral groove or the bottom end of the piston wears out, a gap is made between the bottom end of the piston and the spiral groove so that stable operation of the hydraulic pump cannot be expected.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a hydraulic pump which can make fluid to be linearly discharged with uneven numbers of pistons, and reduce pulsation in the quantity of fluid due to the factors of mechanical characteristic and fluid compression.

It is another object of the present invention to provide a hydraulic pump which can control the quantity of fluid to be discharged in a stable manner.

These and other objects may be achieved by a hydraulic pump including an upper housing with fluid inlet and outlet ports, and a lower housing combined with the upper housing. A driving shaft is inserted into the upper and lower housings such that the driving shaft is rotated. A cylinder block is mounted within the upper housing around the driving shaft such that the cylinder block is rotated together with the driving shaft. Uneven numbers of pistons are equidistantly arranged in the cylinder block such that the pistons reciprocate. Each piston has a ball bearing. A swash plate member is provided at the lower housing. The swash plate

member has a spiral groove for receiving the ball bearing of the piston. The spiral groove of the swash plate member incurs the stroke of the piston. The spiral groove of the swash plate member has a left spiraled portion and a right spiraled portion interconnected by curved portions.

Alternatively, the spiral groove of the swash plate member may be complex-spiraled with a plurality of spiral parts. Each spiral part has spiraled portions interconnected by curved portions. In this structure, the fluid quantity to be discharged can be controlled by changing the stroke of the pistons while tilting the swash plate member and linearized as the spiral groove consists of complex-spiraled structure.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention, and many of the attendant advantages thereof, will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings in which like reference symbols indicate the same or the similar components, wherein:

Fig. 1 is a side elevation view of a hydraulic pump with pistons and a swash plate member according to a first preferred embodiment of the present invention;

Fig. 2 is a perspective view of the swash plate member shown in Fig. 1;

Fig. 3 is a plan view of the swash plate member shown in Fig. 1;

Fig. 4 is a cross sectional view of the swash plate member taken along the I - I line of Fig. 3;

Fig. 5 is a cross sectional view of the swash plate member taken along the II - II line of Fig. 3;

Fig. 6 is a pitch circle developmental view of the spiral groove of the swash plate member shown in Fig. 1;

Fig. 7 is a diagram illustrating displacement and speed of the piston

moving on the spiral groove of the swash plate member shown in Fig. 1;

Fig. 8a is a diagram illustrating positional relation in-between the pistons moving on the spiral groove of the swash plate member shown in Fig. 1;

Fig. 8b is a diagram illustrating speed relation in-between the spiral groove of the swash plate member shown in Fig. 1 and the pistons moving on the spiral groove;

Fig. 9 is a diagram illustrating fluid quantity compensation relation in-between the pistons moving on the swash plate member shown in Fig. 1;

Fig. 10 is a diagram illustrating fluid quantity compensating operations of the first and fifth pistons shown in Fig. 8a;

Fig. 11 is a side elevation view of a hydraulic pump with pistons and a swash plate member according to a second preferred embodiment of the present invention;

Fig. 12 is a perspective view of the swash plate member shown in Fig. 11;

Fig. 13 is a plan view of the swash plate member shown in Fig. 11;

Fig. 14 is a cross sectional view of the swash plate member taken along the I－I line of Fig. 13;

Fig. 15 is a diagram illustrating displacement of the pistons moving on the spiral groove of the position-varied swash plate member shown in Fig. 11;

Fig. 16 is a diagram illustrating the speed of the displaced pistons shown in Fig. 15; and

Fig. 17 is a schematic view illustrating the position-varied state of the swash plate member shown in Fig. 11.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of this invention will be explained with reference to the accompanying drawings.

Fig. 1 is a side elevation view of a hydraulic pump according to a first preferred embodiment of the present invention. The hydraulic pump includes an upper housing 2 with an inner empty space, and a lower housing 4 combined with the upper housing 2 while enclosing the empty space. A driving shaft 6 is inserted into the upper and lower housings 2 and 4 such that it can be rotated by receipt of driving power from a separate power source (not shown). A cylinder block 10 with a plurality of cylinders 8 is mounted within the empty space of the upper housing 2.

The upper housing 2 is provided with a fluid inlet port p1 and a fluid outlet port p2.

A piston 12 is inserted into each of the cylinders 8 such that it can reciprocate therein. The piston 12 has a pocket 14 at its bottom portion. The pocket 14 of the piston 12 receives a ball bearing 16 such that the ball bearing 16 can roll therein.

A seat 18 is formed at the peripheral portion of the pocket 14, and an elastic member 20 is interposed between the pocket 14 and the cylinder block 10. In such a structure, the elastic member 20 presses the piston 12 against the seat 18.

The top end of the driving shaft 6 is positioned at the upper housing 2 while sequentially passing through the lower housing 4 and the cylinder block 10.

A spline is formed at the periphery of the driving shaft 6, and combined with the cylinder block 10 such that the cylinder block 10 can be rotated together with the driving shaft 6.

A swash plate member 24 is provided at the lower housing 4, and exposed to the inner space of the upper housing 2.

A spiral groove 26 is formed at the top side of the swash plate member 24 to partially receive the aforementioned ball bearing 16 held in the pocket 14 of the piston 12. The swash plate member 24 has a center hole 28 for freely passing the driving shaft 6.

Fig. 2 is a perspective view of the swash plate member 24 shown in Fig. 1, Fig. 3 is a plan view of the swash plate member 24, Fig. 4 is a cross sectional view of the swash plate member 24 taken along the I - I line of Fig. 3, and Fig. 5 is a cross sectional view of the swash plate member 24 taken along the II - II line of Fig. 3.

As shown in the drawings, the spiral groove 26 has two spiraled portions 30 and 32 spaced apart from each other with a predetermined distance, and two curved portions 34 and 36 each interconnecting the spiraled portions 30 and 32.

One of the spiraled portions 30 and 32 is processed in the left direction, and the other in the right direction. Fig. 6 illustrates the developed state of the spiral groove 26.

The spiral groove 26 is structured to have a difference in height when viewed from the horizontal side. In case the highest point of the spiral groove 26 is called the "top dead center (TC)" and the lowest point called the "bottom dead center (BC)", the distance between the TC and the BC corresponds to the stroke L of the piston 12.

The TC and the BC are existent at the curved portions 34 and 36, respectively. Particularly when the spiral groove 26 is assumed to be a circle with four sections quartered from three o'clock to nine o'clock in the anti-clockwise direction, as shown in Fig. 3, one curved portion 36 having the TC is biased at the second quarter section, and the other curved portion 34 having the BC is centered around the borderline between the third and fourth quarter sections. In this structure, as shown in Fig. 7, the piston 12 is displaced after passing the TC, and the speed of the piston 12 corresponds to the displacement of the piston 12. Consequently, the fluid discharging area becomes longer than the fluid introducing area. That is, the fluid discharging area is extended as much as the distance of the curved portion 36 biased at the second quarter section.

Fig. 8a specifically illustrates the position of the first to seventh

pistons 12a to 12g moving on the spiral groove 26.

The curved portions 34 and 36, and the spiraled portions 30 and 32 are structured such that the first to seventh pistons 12a to 12g are equidistantly arranged on the spiral groove 26. When the first piston 12a is positioned on the BC, the second to fourth pistons 12b to 12d are positioned at the fluid discharging area, whereas the fifth to seventh pistons 12e to 12g are positioned at the fluid introducing area.

When the driving shaft 6 rotates, as shown in Fig. 8b 1), the speed of the first piston 12a gradually increases at the fluid discharging area. At this time, as shown in Fig. 8b 2) and 3), the second and third pistons 12b and 12c have the same speed . As shown in Fig. 8b 4), the speed of the fourth piston 12d gradually decreases. As shown in Fig. 8b 5), the speed of the fifth piston 12e positioned at the fluid introducing area also gradually decreases. As shown in Fig. 8b 6), the speed of the sixth piston 12f also positioned at the fluid introducing area is kept to be constant at that area. As shown in Fig. 8b 7), the speed of the seventh piston 12g gradually increases.

The pistons 12a to 12g placed at the above positions are rotated along the spiral groove 26 at the same time. Fig. 9 1) to 7) illustrates the quantity of fluid introduced and discharged by the first to seventh pistons 12a to 12g while overlapped with those of the previous pistons, respectively.

Fig. 9 1) illustrates the quantity of fluid introduced and discharged when the first piston 12a begins rotating at the BC. Fig. 9 2) illustrates the quantity of fluid introduced and discharged by the second piston 12b while overlapped with that of the first piston 12a. In the same way, Fig. 9 7) illustrates the quantity of fluid introduced and discharged by the seventh piston 12g. It can be inferred from the above that when the discharged fluid quantities are overlapped, the pulsation phenomenon fades away so that the fluid quantity becomes linear.

Fig. 10 illustrates the quantity of fluid introduced and discharged by

the first and fifth pistons 12a and 12e. The overlapped fluid quantity v1 fills in the area v2 where pulsation incurs so that the discharged fluid quantity becomes linear.

Fig. 11 is a side elevation view of a hydraulic pump according to a second preferred embodiment of the present invention. In this preferred embodiment, the overall components of the hydraulic pump are the same as those related to the first preferred embodiment except that the swash plate member has a different structure.

The swash plate member 240 makes sliding-contact with a seat member 52 such that the inclination degree thereof can be changed.

The seat member 52 is fixed to the upper housing 4 with a circular arc-shaped groove 50. A round sliding member 54 is provided under the swash plate member 240 such that it contacts the circular arc-shaped groove 50.

The sliding member 54 has a hole for excluding any interception when the swash plate member 240 is tilted toward it.

An adjusting member 56 is provided at the upper housing 2 such that the bottom end thereof contacts the top surface of the swash plate member 240.

In order to give the swash plate member 240 the required elastic force, a groove is made at the lower housing 4, and an elastic member 58 is inserted into the groove of the lower housing 4. A contact member 60 is tensioned between the elastic member 58 and the bottom portion of the swash plate member 240. The position of the contact member 60 under the swash plate member 240 corresponds to that of the adjusting member 56 on the swash plate member 240.

The top end of the contact member 60 contacting the swash plate member 240 is shaped with a circular arc to ensure smooth movement of the swash plate member 240 at tilting.

The portion of the swash plate member 240 contacting the contact

member 60 is formed with a groove 62 for preventing the contact member 60 from deviating from its contact position.

The adjusting member 56 is screwed through the upper housing 2, and the top portion of the adjusting member 56 exposed to the outside is structured such that it can be rotated by a wrench or a spanner and, hence, the bottom end of the adjusting member 56 can push the swash plate member 240.

In the above structure, the swash plate member 240 moves upward or downward in accordance with the rotating direction of the adjusting member 56.

When the swash plate member 240 is tilted, the sliding member 54 slides from the seat member 52.

As the inclination degree of the above-structured swash plate member 240 can be controlled, a spiral groove 260 provided at the swash plate member 240 as in the first preferred embodiment is correspondingly structured to be complex-spiraled.

That is, the spiral groove 26 of the swash plate member 24 according to the first preferred embodiment is single-spiraled with two spiraled portions and two curved portions, whereas the spiral groove 260 according to the second preferred embodiment, as shown in Figs. 12 to 14, is complex-spiraled with a plurality of spiral parts each having two spiraled portions and two curved portions.

This structure is to make the moving routes of the ball bearing 16 of the piston 12 to be linear even when the swash plate member 240 is tilted.

Particularly, as shown in Fig. 13, when the routes of the ball bearing 16 moving on the spiral groove 260 are assumed to be divided into A to C, a moving route A' is followed from the moving route A, B' from the moving route B, and C' from the moving route C.

Fig. 14 illustrates the ground for forming such a spiral groove 260. In case the swash plate member 240 is in a horizontal state when viewed on

the basis of the drawing, the ball bearing 16 does not pass the point C'. In contrast, when the swash plate member 240 is tilted by a predetermined angle, the ball bearing 16 passes by the point C'. That is, in the latter case, the pitch circle (P.C.D.) meets a side for forming the spiral groove 260 at a point C', by which the ball bearing 16 pass. When the swash plate member 240 returns to be in the horizontal state, the point C' remains in its position. In this way, A', B', C' and other points can be found and several lines interconnecting A, B, C and other points as well as A', B', C' and other points may be drawn. The lengths of such lines are determined in accordance with the maximum variance angle of the swash plate member 240. Consequently, such lines are continuously joined together and angled by 360 degree to thereby form the spiral groove 260 having a curved surface.

The portion of the spiral groove 260 to be raised is structured to have a width narrower than that of the portion to be lowered. That is, as shown in Fig. 14, the portion of the spiral groove 260 indicated by A, B and C has a width narrower than that of the portion indicated by A', B' and C'. This is because the portion to be lowered has a wider movement range than that of the portion to be raised when the swash plate member 240 is tilted.

Therefore, as shown in Fig. 15, when the curved portion of the spiral line interconnecting A and A' as in the first preferred embodiment is assumed to be the R_1 curve, the curved portion of the spiral line interconnecting B and B' as in the first preferred embodiment to be the R_2 curve, and the spiral line interconnecting C and C' as in the first preferred embodiment to be the R_3 curve, the R_1 to R_3 curves satisfy the following mathematical formula: $R_1>R_2>R_3$.

Since spiral lines to be changed by tilting are existent in the spiral groove 260, the piston 12 moves along the appropriate spiral lines even when the swash plate member 240 is slightly tilted.

Fig. 16 is a graph illustrating variation in the speed of the piston 12 when the moving routes of the piston 12 are indicated by R_1 to R_3 as in Fig.

15. According to the graph, the stroke of the piston 12 are changed in accordance with the inclination degree of the swash plate member 240. This means that as the stroke of the piston 12 are changed, the quantity of fluid discharged are also changed.

Fig. 17 illustrates variation in the tilting angle of the swash plate member 240 due to the adjusting member 56. It can be known from the drawing that as the tilting angle of the swash plate member 240 is changed, the stroke of the piston 12 is changed by D_1. Furthermore, the rolling routes of the ball bearing 16 constantly ensures stable linear fluid discharging at any tilting angle of the swash plate member 240.

As described above, in the inventive hydraulic pump, the spiral groove of the swash plate member has a left spiraled portion and a right spiraled portion interconnected by a curved portion. The spiral groove is provided with bisecting points. One of the bisecting points corresponds to the bottom dead center of the spiral groove. The top dead center of the spiral groove is positioned at the place biased from the other bisecting point to the left spiraled portion. In this structure, pulsation in the quantity of fluid to be discharged can be minimized.

While the present invention has been described in detail with reference to the preferred embodiments, those skilled in the art will appreciate that various modifications and substitutions can be made thereto without departing from the spirit and scope of the present invention as set forth in the appended claims.

WHAT IS CLAIMED IS:

1. A hydraulic pump comprising:

an upper housing having fluid inlet and outlet ports, and a lower housing combined with the upper housing;

a driving shaft inserted into the upper and lower housings such that the driving shaft is rotated;

a cylinder block mounted within the upper housing around the driving shaft such that the cylinder block is rotated together with the driving shaft;

uneven numbers of pistons equidistantly arranged in the cylinder block such that the pistons reciprocate, each piston having a ball bearing; and

a swash plate member provided at the lower housing, the swash plate member having a spiral groove for receiving the ball bearing of the piston, the spiral groove of the swash plate member incurring the stroke of the piston, the spiral groove of the swash plate member comprising a left spiraled portion and a right spiraled portion interconnected by curved portions.

2. The hydraulic pump of claim 1 wherein the spiral groove comprises bisecting points, one of the bisecting points corresponding to a bottom dead center of the piston, a top dead center of the spiral groove being positioned at the place biased from the other bisecting point, the section of the spiral groove with a long peripheral distance between the top and bottom dead centers being the fluid discharging area, the section of the spiral groove with a short peripheral distance being the fluid introducing area.

3. The hydraulic pump of claim 1 wherein the piston comprises a pocket, the ball bearing being positioned within the pocket such that the ball bearing is rotated.

4. The hydraulic pump of claim 1 wherein the piston comprises a seat, an elastic member being interposed between the cylinder block and the seat of the piston to press the piston against the cylinder block.

5. The hydraulic pump of claim 2 wherein the curved portion of the spiral groove is existent in the fluid discharging area and the fluid introducing at the same time.

6. The hydraulic pump of claim 1 wherein the tilting angle of the swash plate member is controlled to change the stroke of the piston.

7. The hydraulic pump of claim 6 wherein the swash plate member comprises a sliding portion placed within the seat member fixed to the lower housing.

8. The hydraulic pump of claim 6 wherein one side of the swash plate member is elastically supported and the opposite side of the swash plate member is pressed by an adjusting member.

9. The hydraulic pump of claim 6 wherein the swash plate member comprises a complex spiral groove for ensuring the linear discharging even when the swash plate member is tilted.

10. The hydraulic pump of claim 9 wherein the width of the complex spiral groove is established such that the fluid discharging area is narrower than the fluid introducing area.

11. The hydraulic pump of claim 9 wherein the complex spiral groove has a plurality of spiral parts adjacent to one another, each spiral part having spiraled portions interconnected by curved portions, the lines interconnecting the spiral parts being moving routes of the pistons from the fluid discharging area to the fluid introducing area.

AMENDED CLAIMS
[received by the International Bureau on 15 May 2000 (15.05.00); original claims 1-11 replaced by new claims 1-5 (2 pages)]

WHAT IS CLAIMED IS:

1. A hydraulic pump comprising:

an upper housing having fluid inlet and outlet ports, and a lower housing combined with the upper housing;

a driving shaft inserted into the upper and lower housings such that the driving shaft is rotated;

a cylinder block mounted within the upper housing around the driving shaft such that the cylinder block is rotated together with the driving shaft;

odd numbers of pistons equidistantly arranged in the cylinder block such that the pistons reciprocate, each piston having a ball bearing; and

a swash plate member provided at the lower housing, the swash plate member having a spiral groove for receiving the ball bearing of the piston, the spiral groove of the swash plate member incurring the stroke of the piston,

wherein the spiral groove of the swash plate member comprises a left spiraled portion, a right spiraled portion interconnected by curved portions, and bisecting points, one of the bisecting points corresponding to a bottom dead center of the piston, a top dead center of the spiral groove being positioned at the place biased from the other bisecting point, the section of the spiral groove with a long peripheral distance between the top and bottom dead centers being the fluid discharging area, the section of the spiral groove with a short peripheral distance being the fluid introducing area.

2. The hydraulic pump of claim 1, wherein the curved portion of the spiral groove is existent in the fluid discharging area and the fluid introducing at the same time.

3. The hydraulic pump of claim 1, wherein the swash plate member comprises a complex spiral groove for ensuring the linear discharging even when the swash plate member is tilted.

4. The hydraulic pump of claim 3, wherein the width of the complex spiral groove is established such that the fluid discharging area is

narrower than the fluid introducing area.

5. The hydraulic pump of claim 3, wherein the complex spiral groove has a plurality of spiral parts adjacent to one another, each spiral part having spiraled portions interconnected by curved portions, the lines interconnecting the spiral parts being moving routes of the pistons from the fluid discharging area to the fluid introducing area.

FIG.1

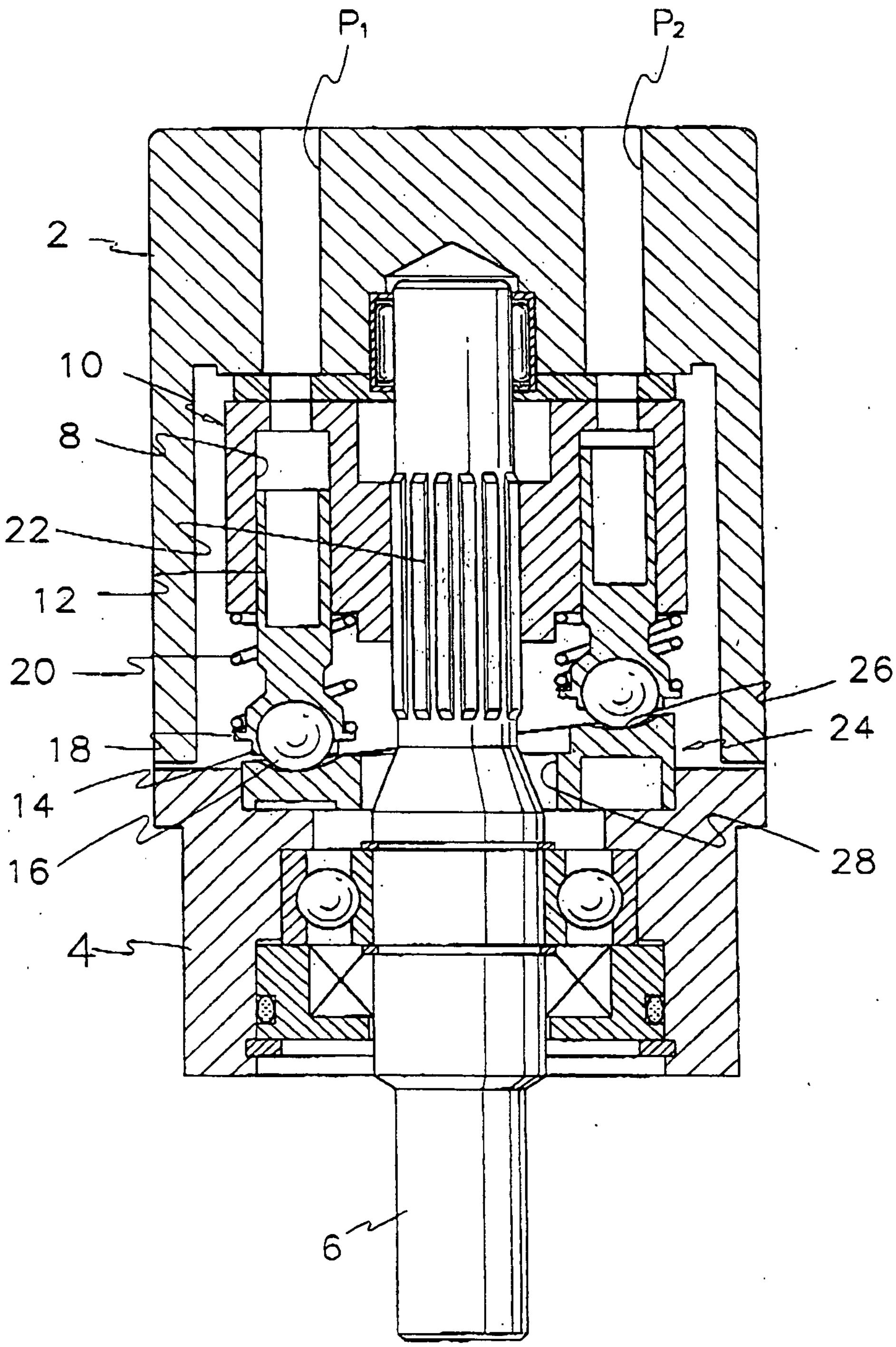


FIG.2

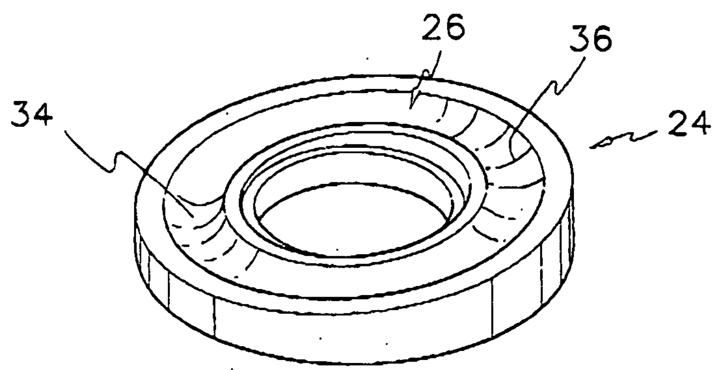


FIG.3

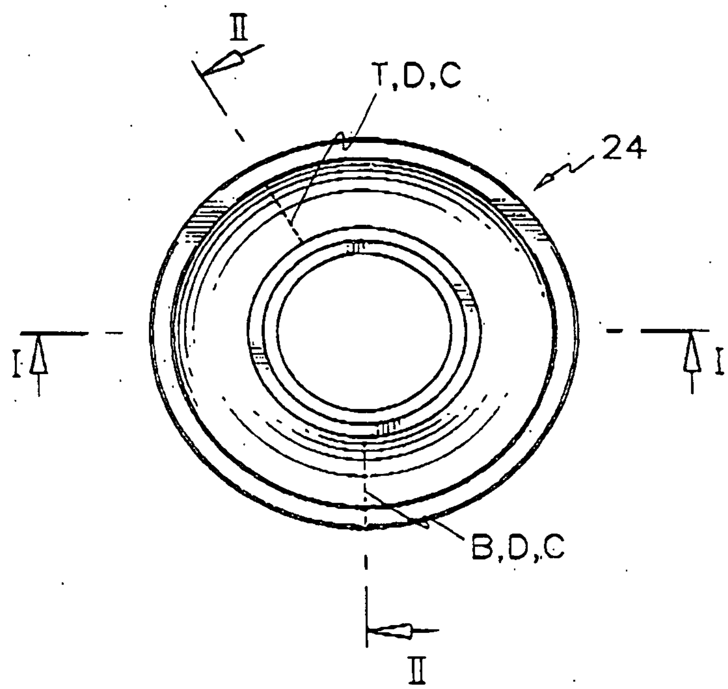


FIG.4

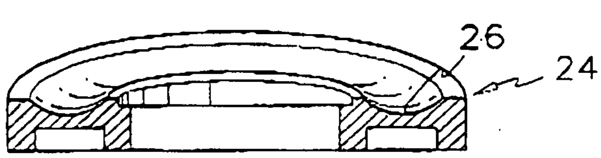


FIG.5

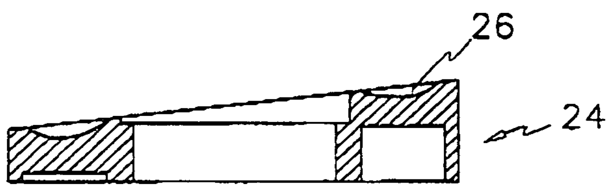


FIG.6

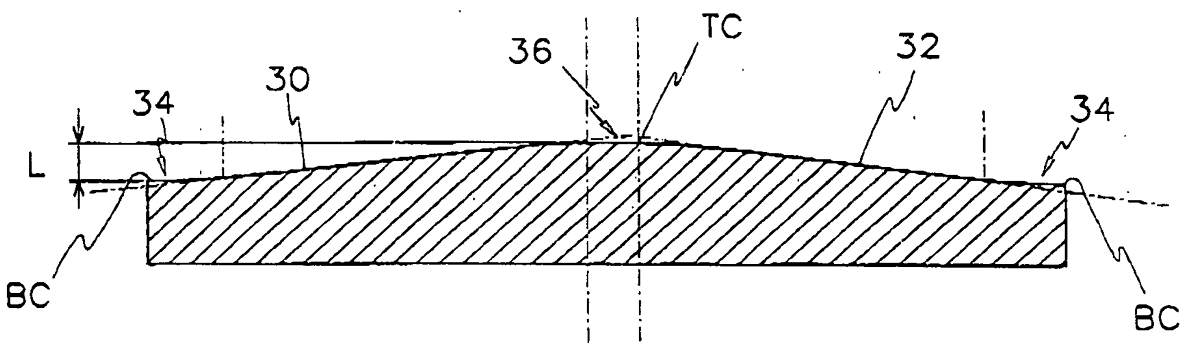


FIG.7

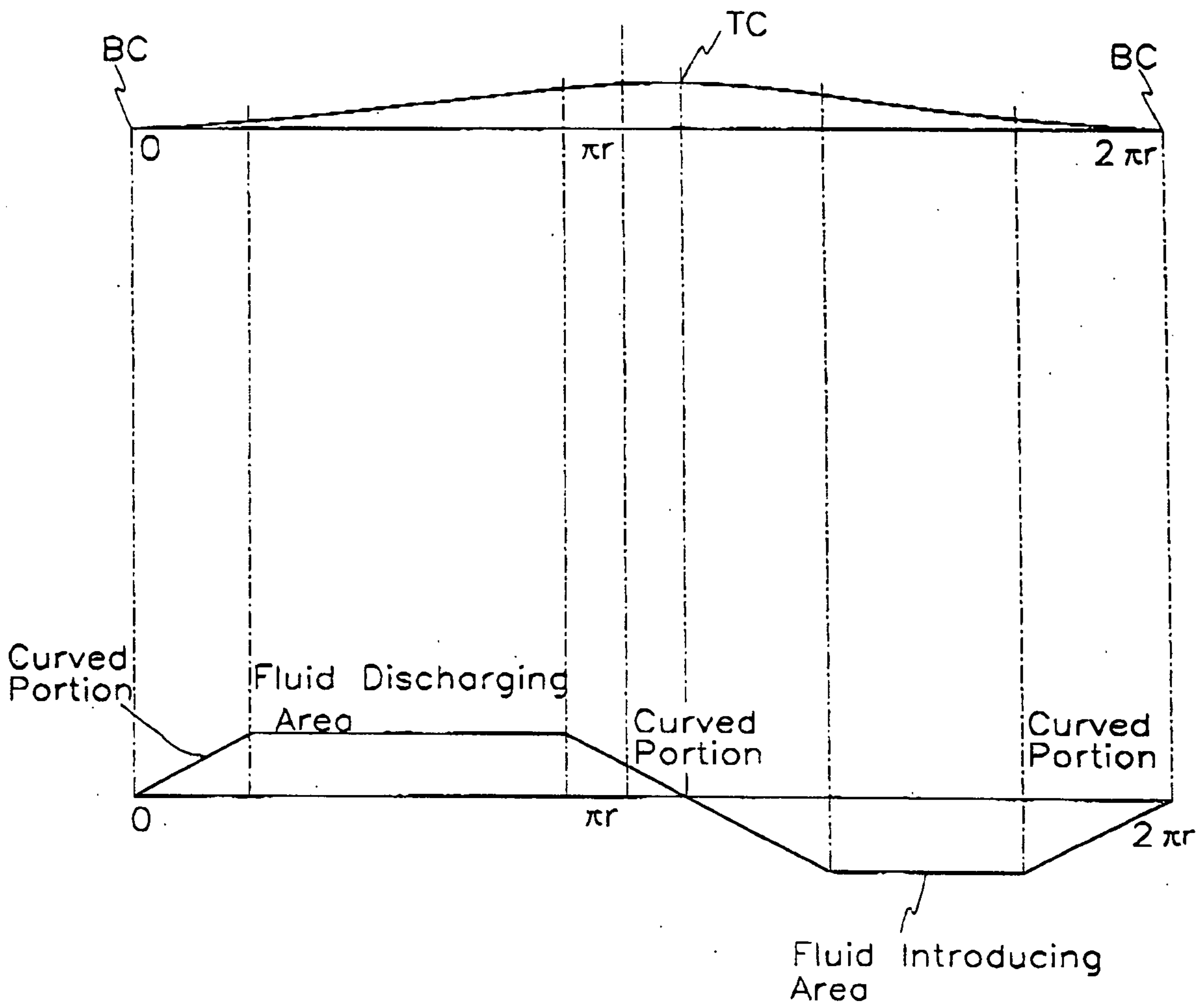

TC
BC
BC
0
πr
2 πr
Curved Portion
Fluid Discharging Area
Curved Portion
Curved Portion
0
πr
2 πr
Fluid Introducing Area

FIG.8A

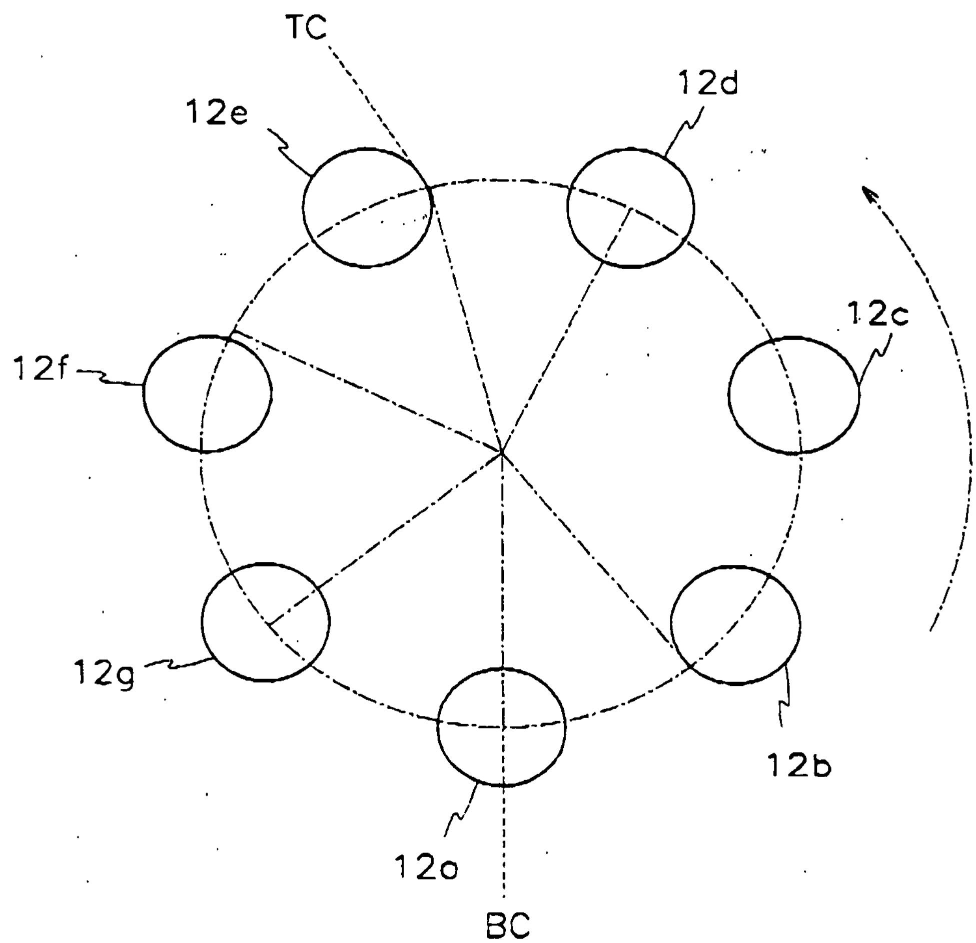


FIG.8B

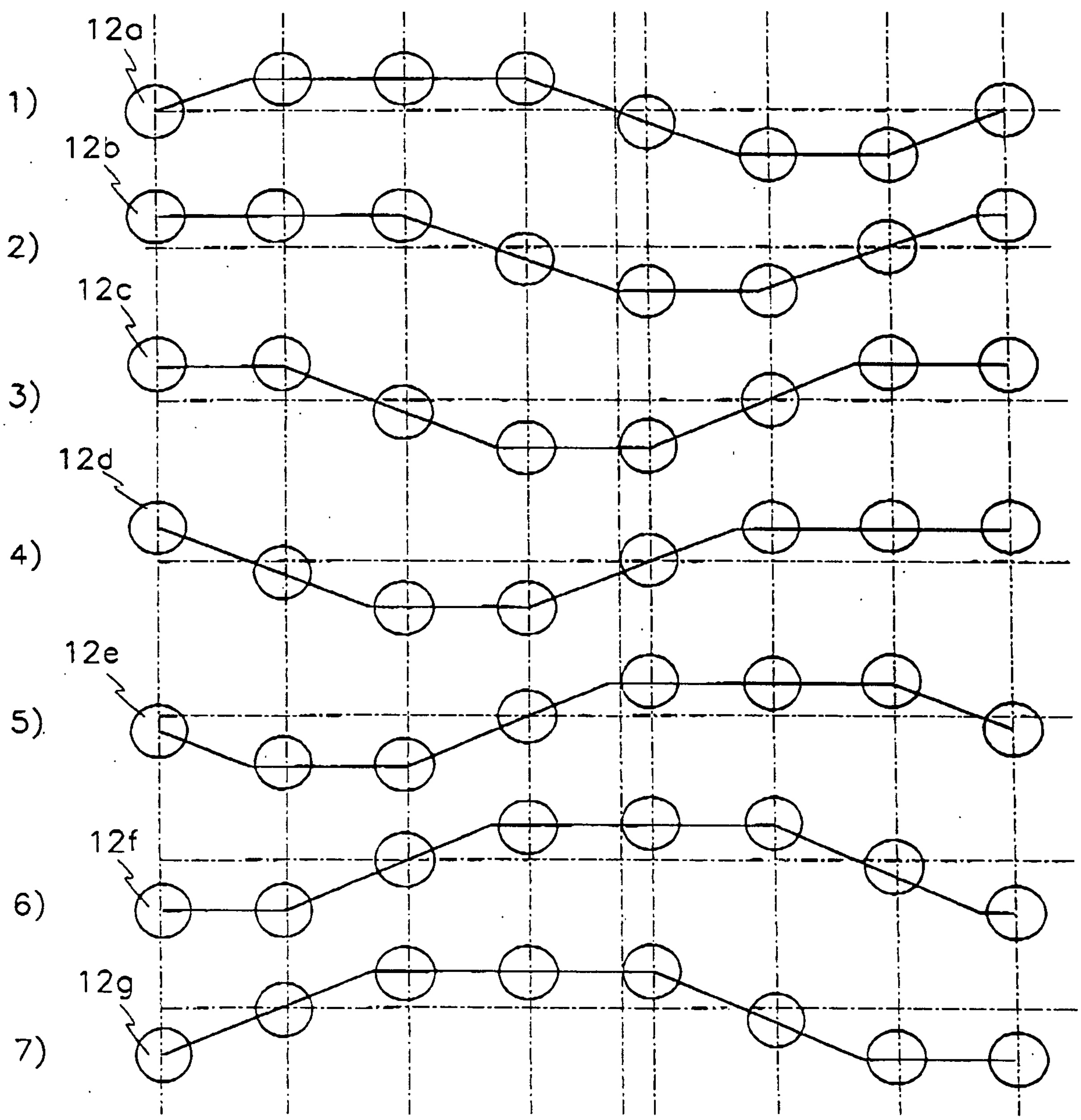


FIG.9

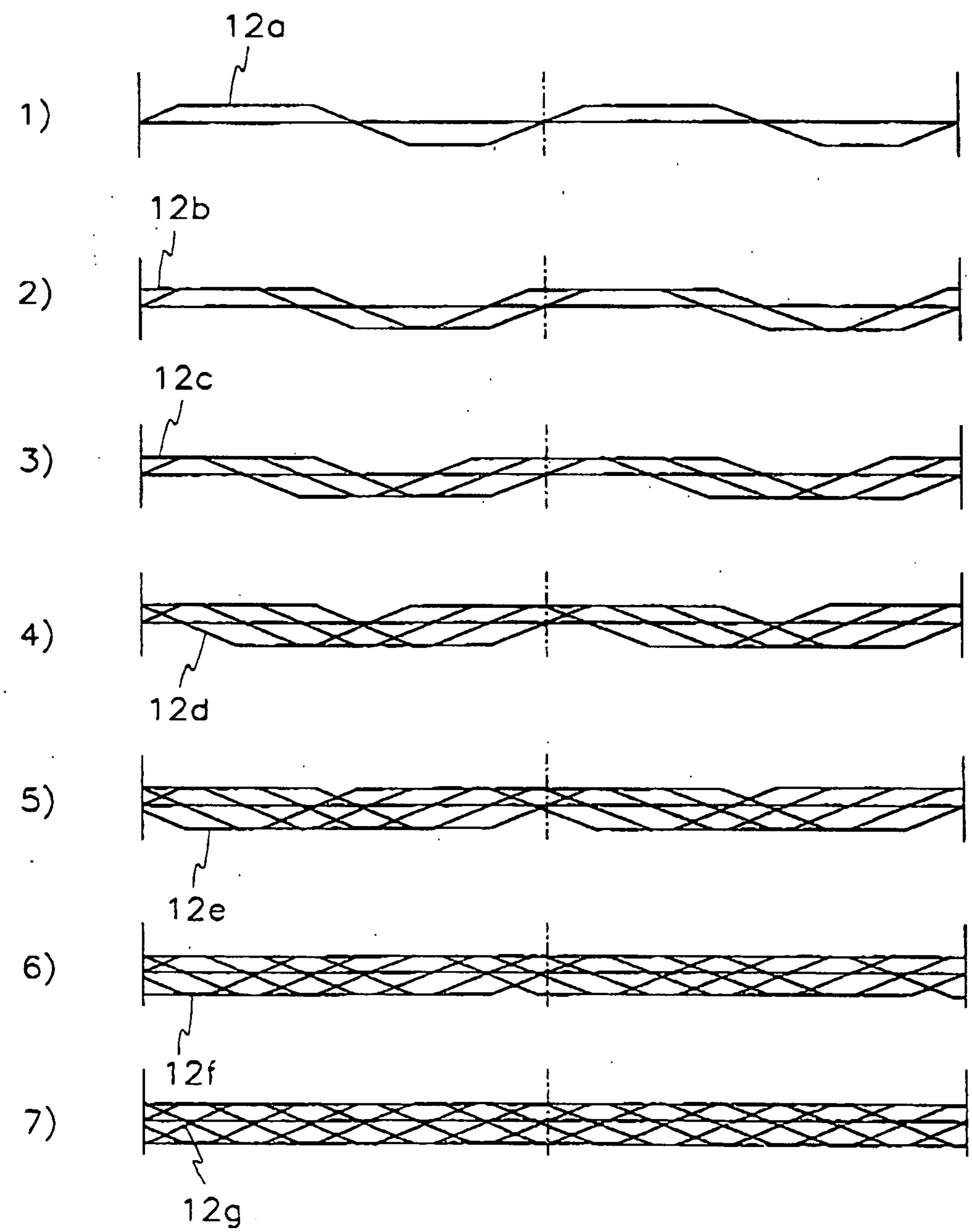


FIG.10

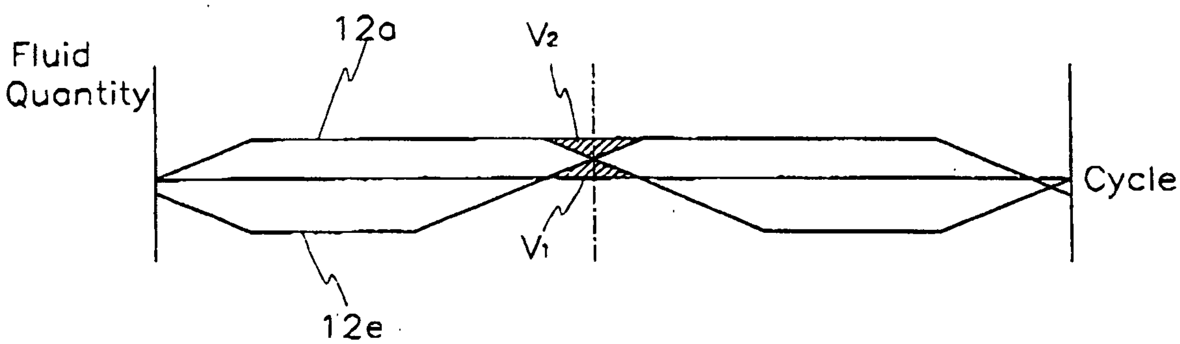


FIG.11

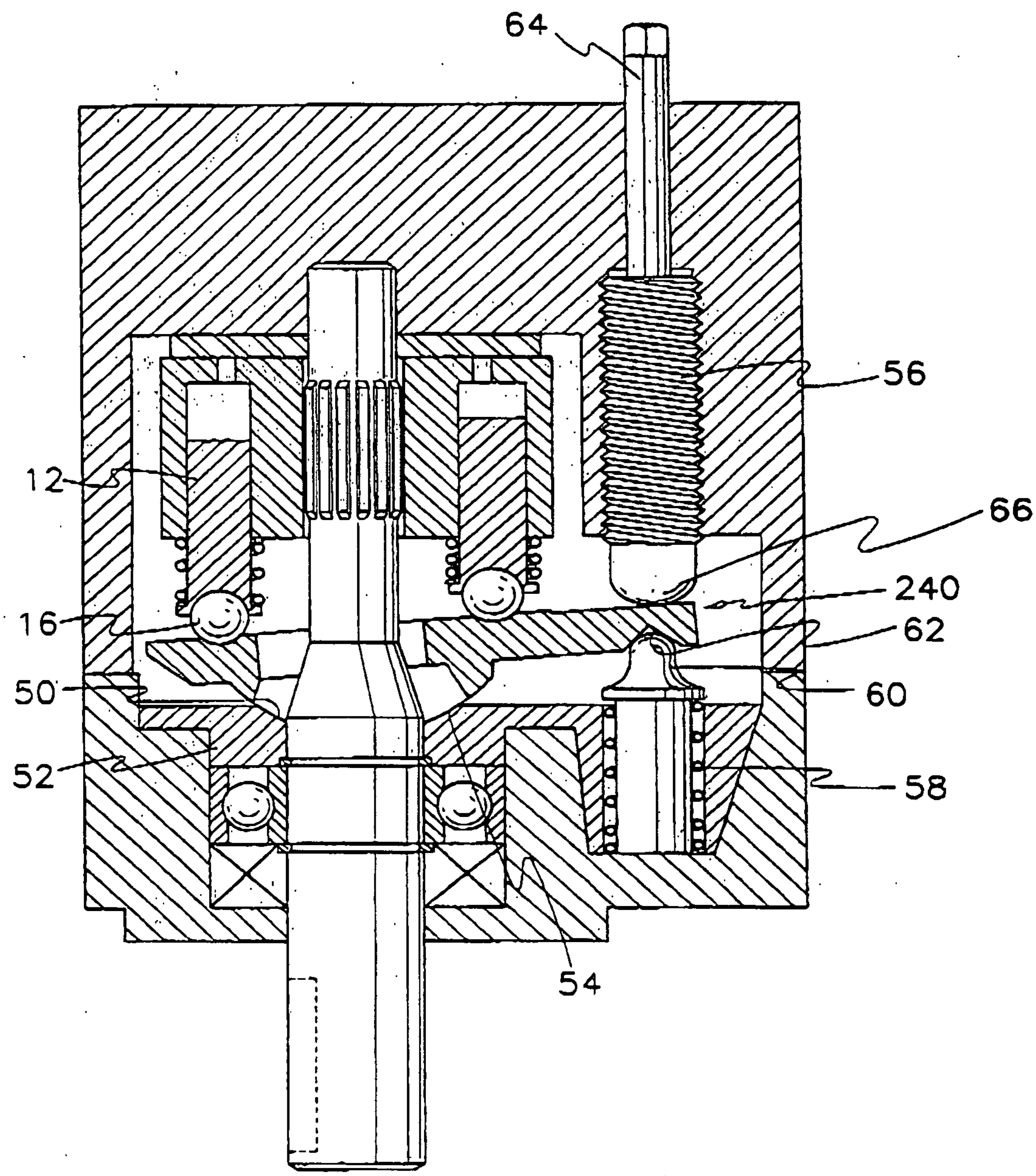


FIG.12

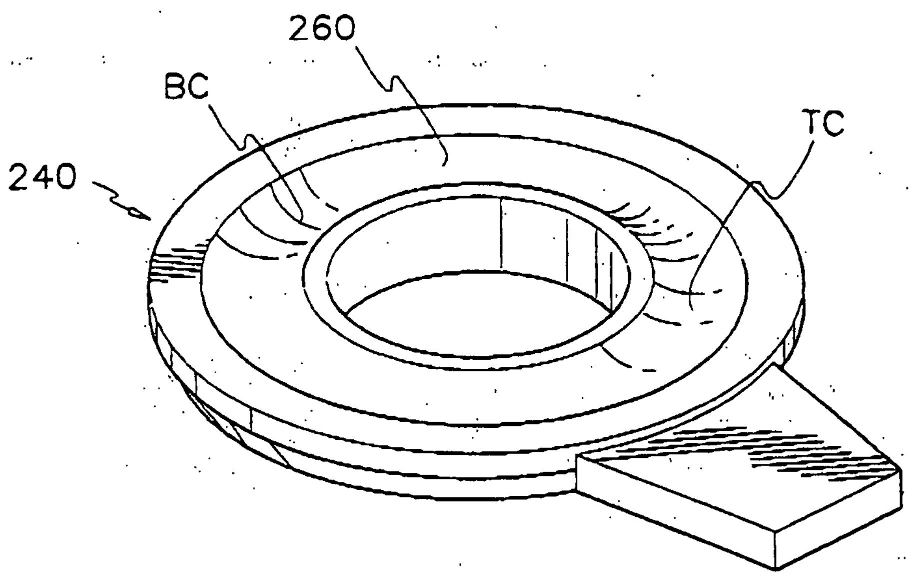


FIG.13

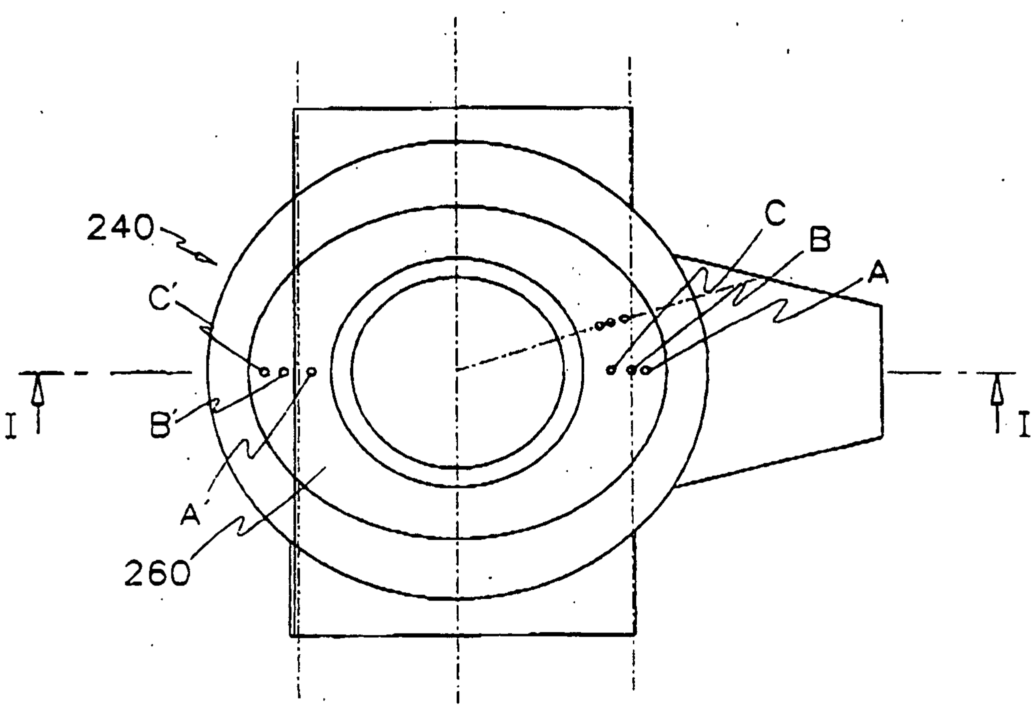


FIG.14

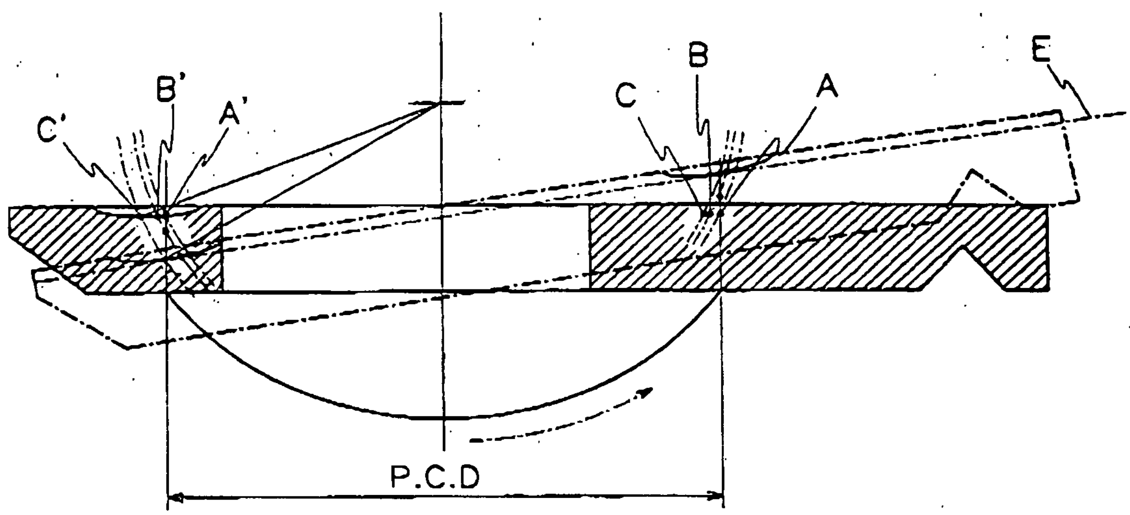


FIG.15

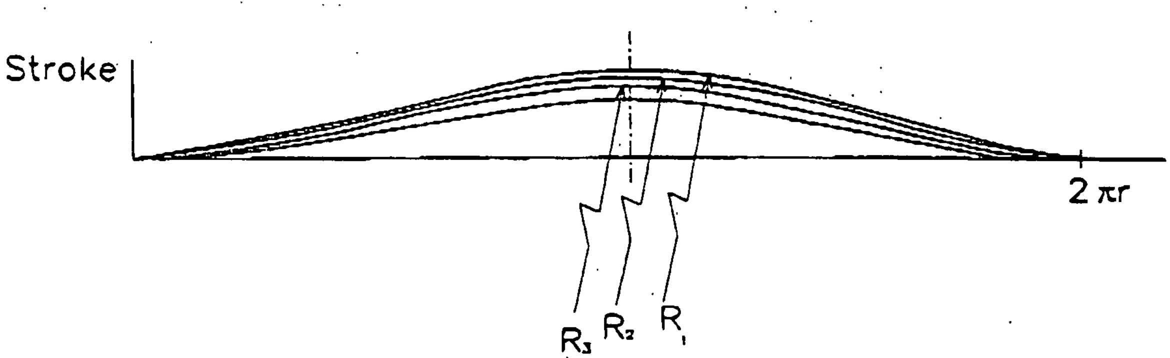


FIG.16

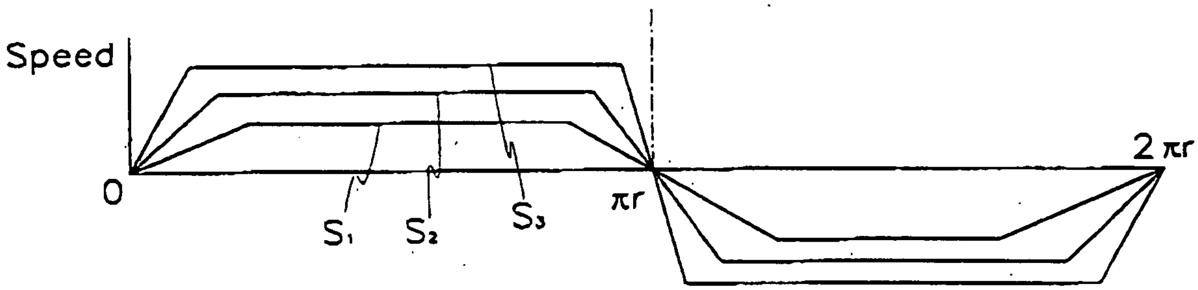
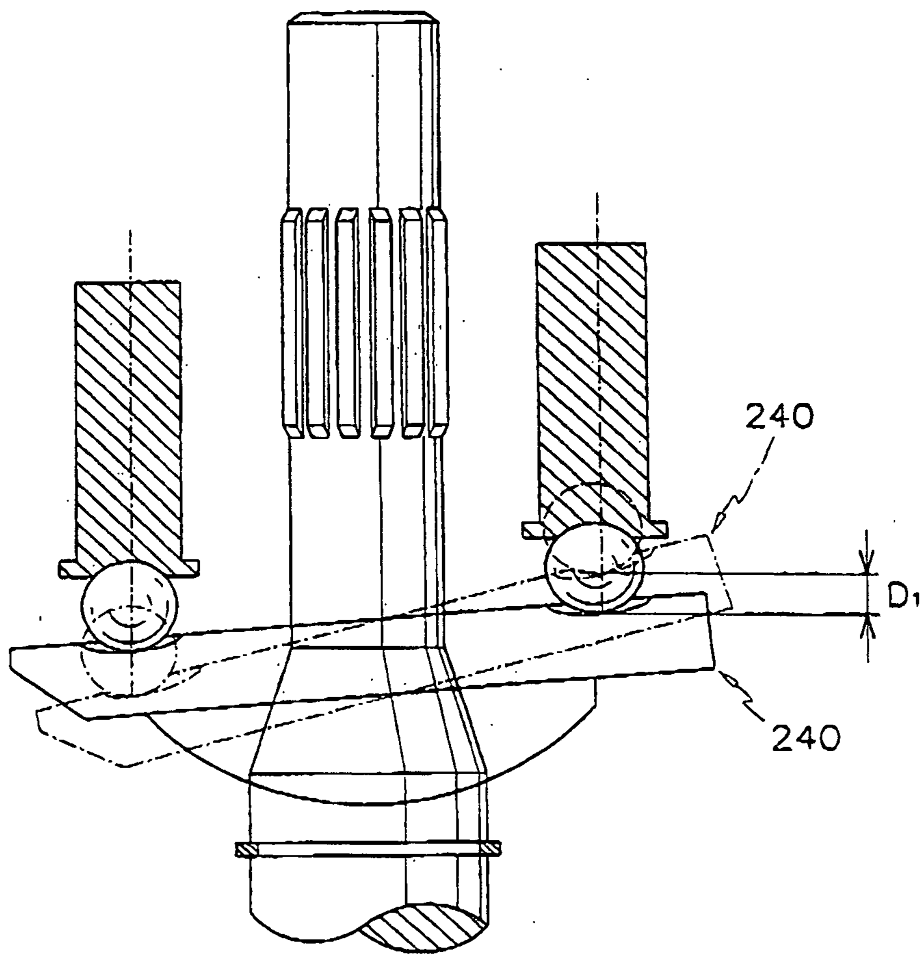


FIG.17



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR99/00746

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 F04B 1/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)
IPC7 F04B 1/20, 1/14

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched
Japanese Utiltity models application for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Patent Abstracts of Japan. JP 1-267368 A(NACHI FUJIKOSHI CORP) 25 October 1989 Figure	1
Y	JP 63-75570 U(TOSHIBA Co.LTD) 19 May 1988 Claim 1-2, Figure 1	1
A	JP 63-75570 U(TOSHIBA Co.LTD) 19 May 1988 Claim 1-2, Figure 1	2

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 MARCH 2000 (04.03.2000)	14 MARCH 2000 (14.03.2000)

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR99/00746

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Patent Abstracts of Japan, JP 5-60058 A(HITACHI CONSTR MACH Co. LTD) 9 Mach 1993 Line 8, page 1, Line 12, page 1, Line 17, page 1	3
X	Patent Abstracts of Japan, JP 3-222876 A(TOYOTA MOTOR CORP) 1 October 1991 Figure	4
X	Patent Abstracts of Japan, JP 3-213674 A(HITACHI CONSTR MACH Co. LTD) 19 September 1991 Line 26, page 1, Figure	4
X	JP 63-75570 U(TOSHIBA Co.LTD) 19 May 1988 Claim 1-2, Figure 1	5
X	Patent Abstracts of Japan, JP 1-267367 A(NACHI FUJIKOSHI CORP) 25 October 1989 Figure	6-11
X	JP 63-121781 U(HOHUKYO Co.LTD) 8 August 1988 Claim 1, Figure 1	6-11